Extraction of GCP from nighttime AVHRR image

Sumio Tamba
Center for Computer and Communications, Hirosaki University
3, Bunkyo-cho, Hirosaki, Aomori, Japan 036-8561
tanba@cc.hirosaki-u.ac.jp

Yoshikazu Iikura
Faculty of Science and Technology, Hirosaki University
3, Bunkyo-cho, Hirosaki, Aomori, Japan 036-8561
iikura@cc.hirosaki-u.ac.jp

Abstract: In this paper, to correct the error, we propose a method to estimate a correction data based on observation data obtained from MUBEX campaign. Many heat spots are correspond to industrial area including steel plant, power plant and so on. Heat spot transmits some kinds of thin cloud because it emits large radiance, so that it is possible to extract GCP from the area under the thin cloud.
keywords: Heat spots, middle-infrared band, GCP, Planck's function

1. Introduction

It is necessary to use GCP (Ground Control Point) data to produce a SST map with a high quality based on NOAA/AVHRR images. Since visible and near-infrared data are available in daytime, we can obtain highly reliable GCP data. In nighttime, we can only use thermal channel data, e.g., middle-infrared (channel 3b) and thermal infrared (channels 4 and 5) data of AVHRR sensor. It is possible to obtain reliable GCP data when a temperature difference between land and sea is large. However, reliability of GCP deteriorates when the difference is small. In order to make a precise SST map from AVHRR image observed in nighttime, it is necessary to obtain some reliable GCP data. Channel 3b data of AVHRR is used for a detection of forest fire[1], so it is possible to detect heat spots effectively from the data. Fig. 1 shows Planck's function for thermal channels of NOAA/AVHRR sensor, and this figure suggests the principle of fire detection.

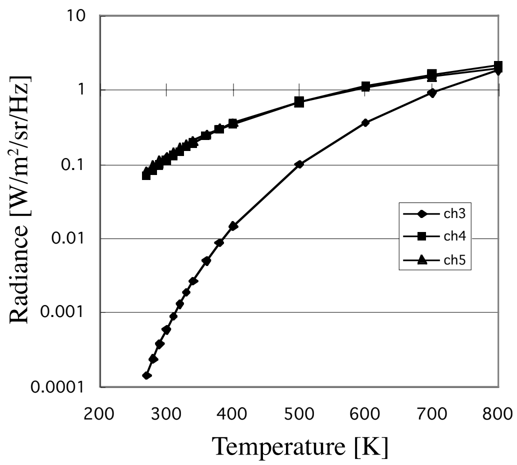

Fig. 1 Planck's function for thermal channels of NOAA/AVHRR sensor.

In this paper, we propose an algorithm to detect heat spots based on the brightness temperature difference between channels 3b and 4 in nighttime. As detection target, we selected artificial heat spots such as generating power plants because the locations of these plants are known. Heat spots have a characteristic of transmitting thin cloud such as altostratus. We demonstrate that GCP can be obtained from the area covered by thin cloud by using hot spots.

2. Test image data

In order to demonstrate the effectiveness of the proposed GCP extraction method for nighttime AVHRR images, six nighttime AVHRR images during June and December, 2002 were selected from the NOAA/AVHRR image archiving system at the Institute of Industrial Science, University of Tokyo. This image set is including a summer season image obtained under a special condition that temperatures of the ocean and the land almost become the same. The collected dates of these images are the follows: 2002. 6. 3, 02[UT], 2002. 8. 1, 01[UT], 2002. 9. 12, 02[UT], 2002. 10. 5, 02[UT], 2002. 10. 6, 02[UT], 2002. 11. 14, 01[UT], 2002. 12. 3, 01[UT].

Fig. 2 shows a nighttime thermal image (channel 4 brightness temperature) in August. The vague outline of the Japanese islands appeared in the image. Fig. 3 shows a nighttime thermal image in December, and land-sea boundary is clear in the image.

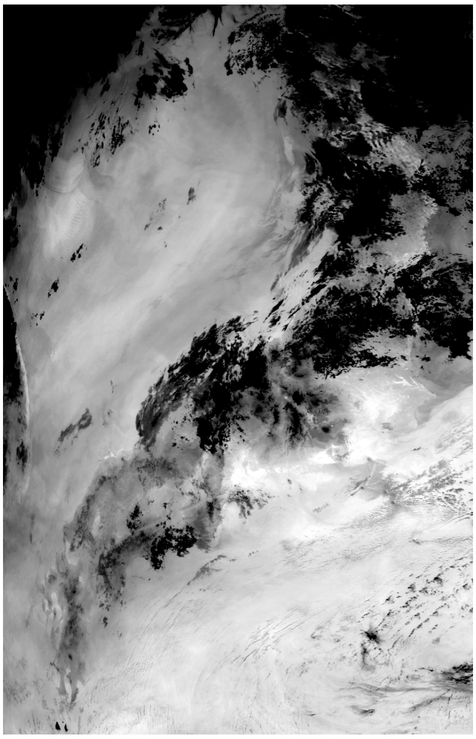

Fig. 2 Channel 4 brightness temperature image (2002. 8. 1, 01[UT]) around Japan. Geometrical correction is not applied.

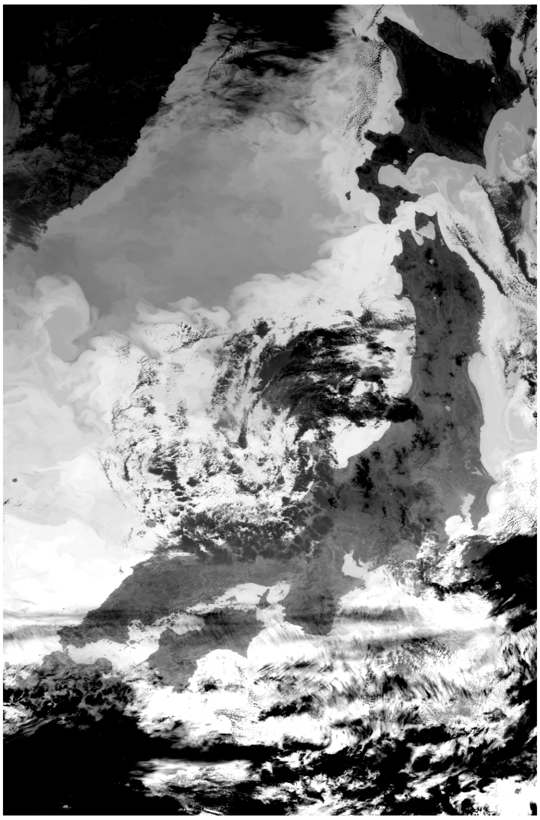

Fig. 3 Channel 4 brightness temperature image (2002. 12. 3, 01[UT]) around Japan. Geometrical correction is not applied.

3. Detection Procedure

At first, a subtraction image ΔT34 is made by T3 - T4, where, T3: channel 3 brightness temperature, T4: channel 4 brightness temperature, and ΔT34: T3-T4. Some heat spots are selected from the ΔT34 image by visual inspection, and it is confirmed that these spots are located in an industrial area including power plants and ironworks by referring map information as GIS data.

Fig. 4 shows a sub-image selected from ΔT34 image on December, which includes some heat spots. This area is a part of industrial area in Chiba Prefecture. This sub-image

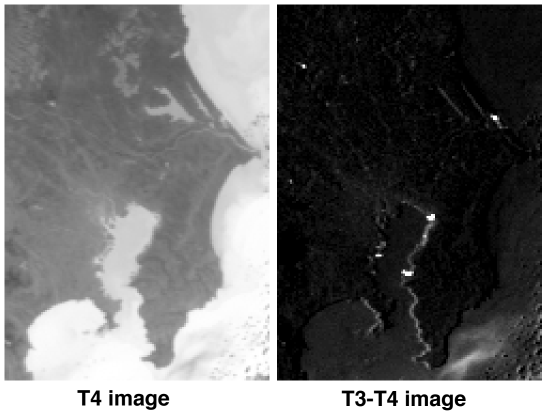

Fig. 4 Sub-image of figure 3, which includes some heat spots. Left image is channel 4 brightness temperature image, and right image is brightness temperature difference (T3-T4) image.

LINE \ PIXEL	1609	1610	1611	1612	1613	1614	1615
2871	67	73	79	74	156	201	86
2872	159	546	220	105	217	163	51
2873	452	1634	1550	1934	1590	465	13
2874	110	215	836	2093	1806	192	-1
2875	186	141	99	127	106	73	74
2876	143	155	114	106	114	66	39
2877	117	204	137	76	40	14	13

UNIT: deg.Cx100

Fig. 5 Pixel values of T3-T4 around a heat spot.

LINE \ PIXEL	1609	1610	1611	1612	1613	1614	1615
2871	0	0	0	0	0	0	0
2872	0	0	0	0	0	0	0
2873	0	1634	1550	1934	1590	0	0
2874	0	0	0	2093	1806	0	0
2875	0	0	0	0	0	0	0
2876	0	0	0	0	0	0	0
2877	0	0	0	0	0	0	0

UNIT: deg.Cx100

Fig. 6 Detection result by the proposed method. This result is obtained from data in figure 5.

is not geometrically corrected. Fig. 5 is the dump result of pixel values in a mask window with 7 pixels by 7 pixels around the heat spot in the Fig. 4. We can find a range of ΔT34 value extend between 8 deg. K and 21 deg. K.

In order to detect heat spot areas from the test images, the following procedure is applied for the selected target areas.

Step 1: Calculate a mean value m0 by averaging all pixel values in the target window area,

Step 2: Select pixels which value is greater than m0,

Step 3: Calculate a mean value m1 by averaging values of the selected pixels,

Step 4: Extract pixels which value is greater than m1 as heat spot pixels.

Fig. 6 shows a heat spot obtained according to the procedure above.

Fig. 7 is other example sub-image selected from DT34 image on November. All area of this sub-image is covered by a thin altostratus cloud, but we can find some heat spots in this cloud image. Fig. 8 is the dump result of pixel values (T3-T4) around the heat spot in the Fig. 7. The pixel values (T3-T4) in Fig. 8 is greater than those in Fig. 8. This means that the value T3-T4 under a thin cloud becomes greater than it under clear sky condition. Fig. 9 shows a heat spot detected by the procedure described above.

The result shows that it is possible to detect the heat spot under cloudy condition by the proposed procedure.

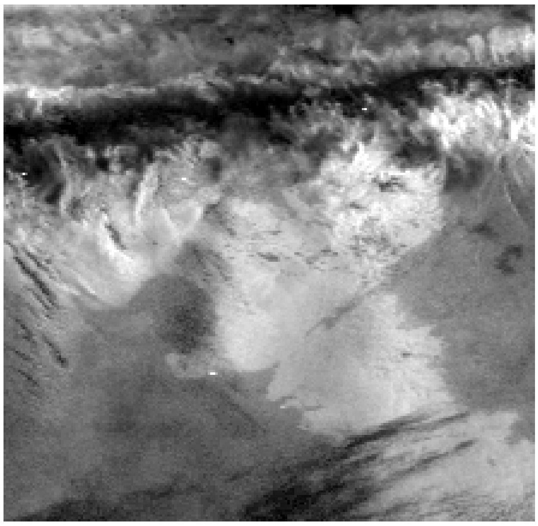

Fig. 7 An example image including a heat spot under thin high cloud area.

PIXEL

LINE	1161	1162	1163	1164	1165	1166	1167
3125	1340	1340	1439	1439	1384	1347	1414
3126	1275	1275	1374	1395	1362	1324	1369
3127	1381	1330	1514	1536	1489	1340	1302
3128	1352	1192	1558	2194	2461	1643	1258
3129	1210	1127	1149	1210	1188	1231	1192
3130	995	1106	1127	1106	1167	1042	1106
3131	898	973	1063	1084	1167	1103	1124

UNIT: deg.Cx100

Fig. 8 Pixel values of T3-T4 around a heat spot under thin high cloud area.

PIXEL

LINE	1161	1162	1163	1164	1165	1166	1167
3125	0	0	0	0	0	0	0
3126	0	0	0	0	0	0	0
3127	0	0	1514	1536	0	0	0
3128	0	0	1558	2194	2461	1643	0
3129	0	0	0	0	0	0	0
3130	0	0	0	0	0	0	0
3131	0	0	0	0	0	0	0

UNIT: deg.Cx100

Fig. 9 Detection result of the heat spot under thin high cloud area. This result is obtained from data in figure 8.

4. Conclusion

By using the nighttime brightness temperature difference between channel 3b (middle infrared band) and channel 4 (thermal infrared band) of AVHRR sensor aboard NOAA-16 satellite, we proposed a procedure to detect high temperature industrial sources. By referring GIS information, we confirmed that the industrial sources are appeared in the image as a heat spot, which is a small high temperature area. This procedure can also be applied to detecting a volcano, which is one of natural heat spots, as same as artificial heat spots.

Heat spot emits strong radiation, so that the emitted radiation transmits through a thin cloud. Our result demonstrates that GCP can be obtained from the cloud area by using heat spot as a detection target.

It is possible to apply this procedure to MODIS data by Terra/Aqua satellites because MODIS sensor bands include all five bands of AVHRR sensor. To construct a database for heat spot locations is extremely important for a AVHRR image navigation. In our plan, we will construct the database based on MODIS data.

References

[1] Robinson, J. M., Fire from space: global fire evaluation using infrared remote sensing, International Journal of Remote Sensing, 12, 3-24, 1991.